# PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-202265
(43)Date of publication of application : 04.08.1995

(51)Int.Cl. H01L 33/00

(21)Application number : 05-354572
(22)Date of filing : 27.12.1993

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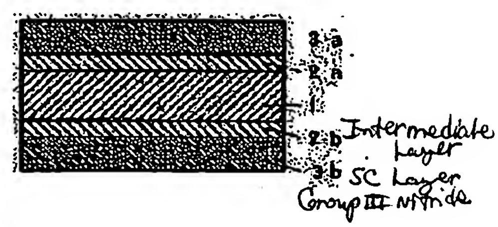
## (54) MANUFACTURE OF GROUP III NITRIDE SEMICONDUCTOR

(57)Abstract:
PURPOSE: To obtain two semiconductors formed of group III nitride semiconductor by forming two semiconductor layers made of the group III nitride semiconductor on intermediate layers formed on both side surfaces if a sapphire board, removing only the two intermediate layers by wet etching, and peeling the two semiconductor layers from the board.
CONSTITUTION: Intermediate layers 2a, 2b made of zinc oxide are formed on both side surfaces of a sapphire board 1. Two semiconductor layers 3a, 3b made of group III nitride semiconductor are respectively formed on the layers 2a, 2b. Only the layers 2a, 2b are removed by wet etching using solution for etching only the zinc oxide to peel the layers 3a, 3b from the board 1. Thus, two semiconductors made of the group III nitride semiconductor can be easily manufactured.




LEGAL STATUS

[Date of request for examination] 25.12.2000

[Date of sending the examiner's decision of rejection] 04.12.2001

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

## CLAIMS

[Claim(s)]
[Claim 1] The interlayer who changes from a zinc oxide (ZnO) to both sides of silicon on sapphire is formed. the interlayer top formed in both sides of silicon on sapphire — III Group nitride semiconducto (AlxGaYIn1-X-YN;X=0, Y= 0, and X=Y=0 are included) Two becoming semiconductor layers are formed. from — By removing only the two aforementioned interlayers by wet etching using the solution which **********s only a zinc oxide the two aforementioned semiconductor layers are exfoliated from the aforementioned silicon on sapphire — making — III Group nitride semiconductor (AlxGaYIn1-X-YN;X=0 Y= 0, and X=Y=0 are included) from — the manufacture method of obtaining the becoming semiconductor of two sheets
[Claim 2] In a claim 1, the aforementioned interlayer's thickness is 10nm - 1 micrometer.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention is III. It is related with the method for obtaining the epitaxial substrate of a group nitride semiconductor.
[0002]
[Description of the Prior Art] Conventionally, it is GaN as blue light emitting diode. The thing using the compound semiconductor of a system is known. The GaN Since the compound semiconductor of a system is a transited [ directly ] type, it attracts attention from that luminous efficiency is high, making into the luminescent color blue it is [ blue ] one in three primary colors of the light, etc.
[0003] Moreover, general formula AlxGaYIn1-X-YN (X= 0, Y= 0, and X=Y=0 are included) III expressed The light emitting device using the group nitride semiconductor is known. This semiconductor has the energy band gap corresponding to the wavelength of 200-650nm, and is a transited [ directly ] type. Especially this semiconductor attracts attention as a light-emitting-device material of a visible short wavelength field and an ultraviolet region.
[0004]
[Problem(s) to be Solved by the Invention] The crystal of this semiconductor is near growth temperature, and since the equilibrium vapor pressure of the nitrogen of a composition element is very high, creation of a bulk crystal is very difficult. Therefore, that to which this semiconductor grew the semiconductor epitaxially on silicon on sapphire is used. Therefore, always, various kinds of semiconductor devices using the above-mentioned semiconductor are used, where silicon on sapphire i attached. Since the semiconductor device has attached silicon on sapphire, the installation structure of an electrode, the ejection structure of light, etc. have restrictions.
[0005] If it says by the attaching structure of an electrode, since silicon on sapphire is an insulator, it cannot attach an electrode so that p layers and n layers may be put between sand UJJI structure. Therefore, in the best layer, it is necessary to form the electrode to p layers and n layers. For that, the slot for insulating separation is formed or the process which forms the hole for forming the electrode to a lower layer is needed for an excess. Moreover, with this electrode structure, current is poured in in parallel with a lower layer field. For this reason, while resistance became large and the voltage drop became large, there was a problem that the calorific value of the Joule's heat became large.
[0006] The purpose of this invention is AlxGaYIn1-X-YN (X= 0, Y= 0, and X=Y=0 are included). III expressed It is manufacturing the substrate of a group nitride semiconductor easily. Moreover, other purposes of this invention are constituting light emitting diode using the single crystal substrate obtained by making it such.
[0007]
[Means for Solving the Problem] this invention consists of the following process. The interlayer who changes [ 1st ] from a zinc oxide (ZnO) to both sides of silicon on sapphire is formed. the 2nd — both sides of the silicon on sapphire — the interlayer top of two formation **** — III Group nitride semiconductor (AlxGaYIn1-X-YN;X=0, Y= 0, and X=Y=0 are included) from — two becoming semiconductor layers are formed two semiconductor layers are exfoliated from silicon on sapphire by removing only two interlayers by wet etching using the solution which ***********s [ 3rd ] only a zinc oxide — making — III Group nitride semiconductor (AlxGaYIn1-X-YN;X=0, Y= 0, and X=Y=0 are included) from — the becoming semiconductor is obtained
[0008]
[Function and Effect(s) of the Invention] The lattice constant of a zinc oxide (ZnO) is sapphire and III.

Group nitride semiconductor (AlxGaYIn1-X-YN;X=0, Y= 0, and X=Y=0 are included) III good on near ar silicon on sapphire to a lattice constant It functions as a buffer layer into which a group nitride semiconductor can be grown up. Moreover, it is III of two sheets at once by removing only this interlayer by etching. A group nitride semiconductor substrate can be obtained. Thus, III good in this invention It becomes possible to manufacture a group nitride semiconductor wafer.

[0009]

[Example] Hereafter, this invention is explained based on a concrete example. Drawing 1 - drawing 3 a process drawings having shown how to manufacture the gallium-nitride compound semiconductor (Gal of this invention. As shown in drawing 1 , the silicon on sapphire 1 which has the field direction of a direction (0001) was prepared, and organic chemicals, such as a methanol, washed the silicon on sapphire 1. Then, silicon on sapphire 1 was set in the chamber of RF sputtering system, and the chamber was exhausted to the vacuum. Then, the spatter of the target of ZnO was carried out by the mixed gas of an argon and oxygen, and as shown in drawing 2 , the interlayers 2a and 2b who consist c ZnO were formed in both sides of silicon on sapphire 1 by 100nm in thickness. These interlayers 2a an 2b had the strong amount of preferred orientation to c shaft orientations.

[0010] Next, the silicon on sapphire 1 in which Interlayers 2a and 2b were formed was set in the chamber of halogen transport apparatus. And after exhausting a chamber to a vacuum, nitrogen gas wa introduced and silicon on sapphire 1 was heated in temperature of 1000 degrees C which can grow a GaN single crystal. At this time, the amount of preferred orientation of Interlayers' 2a and 2b ZnO improves further, and it becomes possible to grow up GaN of a single crystal on these interlay rs 2a ar 2b. GaCl which Ga and the hydrogen chloride (HCl) were made to react and was generated at the elevated temperature as material gas of a gallium (Ga) was used. Moreover, ammonia was used as material gas of nitrogen (N). GaCl and ammonia were supplied to the front face of silicon on sapphire 1, and GaN was grown up. As shown in drawing 3 , the semiconductor layers 3a and 3b which consist of GaN with a thickness of 300 micrometers by growth of 5 hours were formed in both sides of silicon on sapphire 1 through Interlayers 2a and 2b.

[0011] Next, the silicon on sapphire 1 in which Interlayers 2a and 2b and the semiconductor layers 3a and 3b were formed was dipped in hydrochloric-acid system etchant, and temperature of etchant was made into 60 degrees C. And it applied to the ultrasonic washer for about 10 minutes, and Interlayers 2 and 2b were etched. Thereby, the semiconductor layers 3a and 3b of GaN were able to be made to separate from silicon on sapphire 1. The obtained semiconductor layers 3a and 3b showed n-type-conduction nature, the free electron concentration in a room temperature was abbreviation 3x1017cm-3, and mobility was about 400cm2 / V-s.

[0012] Next, light emitting diode 10.was manufactured by the MOCVD method by using one semiconductor layer 3 as a substrate among the semiconductor layers 3a and 3b with a thickness of 300 micrometers. Next, the manufacture method of the light emitting diode 10 of this structure is explained. The above-mentioned light emitting diode 10 is an organometallic compound vapor growth (it is described as "MOVPE" below). It was manufactured by the vapor growth to depend. the used gas — NH3 Carrier gas H2 and trimethylgallium (Ga3 (CH3)) (it is described as "TMG" below) Trimethylaluminum (aluminum3 (CH3)) (it is described as "TMA" below) A silane (SiH4), bis (cyclopentadienyl) magnesium (Mg2 (C5H5)) (it is described as "Cp2Mg" below), and diethylzinc (it is described as "DEZ" below) it is .

[0013] It is MOVPE about the semiconductor substrate 3 of GaN. H2 and NH3 after setting in the chamber of equipment and exhausting the inside of a chamber to a vacuum The semiconductor substrate 3 was heated in temperature of 1000 degrees C, passing. At this time, it is NH3. It passes for preventing sublimation of GaN from the semiconductor substrate 3.

[0014] H2 [ next, ] — a part for 20 liter/, and NH3.A part for 10 liter/, and TMG a part for 1.7x10 -four mol/, and H2 — 0.86 ppm up to — diluted silane (SiH4) It came out for 200 ml/comparatively, it supplied for 20 minutes, and the buffer layer 4 which consists of n type GaN was formed in the thickness of 1 micrometer.

[0015] next, silicon on sapphire 1 900 degrees C — carrying out — H2 A part for 20 liter/, and NH3 A part for 10 liter/, and TMG 1.7x10 -four-mol a part for /and CP2Mg it comes out for 2x10 -seven-mol/comparatively, it supplies for 10 minutes, and is shown in drawing 5 — as — thickness 0.5-micrometer GaN from — the layer 5 which changes was formed In this state, 5 [ i-layer ] is an insulator

[0016] Next, the electron ray was uniformly irradiated this i layer 5 using reflection-electron line diffraction equipment. The irradiation conditions of an electron ray are 10kV of acceleration voltage, and

a specimen current. They are 1microA, traverse-speed 0.2 mm/sec of a beam, beam-diameter 60micrometerphi, and degree of vacuum 2.1 x10-5Torr. By irradiation of this electron ray, 5 is resistivi 108 i layers. It became p conduction-type semiconductor with a resistivity [ cm ] of 40ohms from the insulator more than omegacm. Thus, p layer 5 which shows p conduction type is obtained. Thus, the wafer of multilayer structure as shown in drawing 5 was obtained.

[0017] Next, as shown in drawing 6 , gold (Au) was made 5, the vacuum evaporationo of the p layers (aluminum) of the aluminum was made to the semiconductor substrate (n layers) 3, and the diameter formed the electrodes 7 and 6 of 1mmphi, respectively. Thus, n layer 3 of the formed light emitting dio 10 of pn junction and the series resistance of n layer 4 were 0.2ohms.

[0018] Moreover, when n layers of electrodes to 3 were formed in the hole in the light emitting diode o structure conventionally which formed p layers of holes which result in 3 n layers at right angles to the field of 5, n layers of n layers of series resistance of 4 were 50ohms with 3. The resistance of the light emitting diode of this example is decreasing to 1/250 to the resistance of the conventional light emitti diode.

[0019] The emission spectrum of the light emitting diode 10 of this example was observed. The result i shown in drawing 7 . Drive current is 10mA. The peak appeared in wavelength of about 450nm, and, as for the luminescence wavelength property, the luminescent color was blue. Luminous efficiency improved to double precision to the conventional light emitting diode.

[0020] In the above-mentioned example, although an interlayer's 2 thickness was set to 100nm, it can be used in 10nm - 1 micrometer. In the above-mentioned example, although the light emitting diode of pn structure was shown, this invention is applicable also to the light emitting diode of pin structure and MIS structure. Moreover, a semiconductor can apply this invention also by InGaN besides GaN, and AlGaN. Moreover, a semiconductor may consist of heterojunctions of a different-species semiconducto material.

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## DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]
[Drawing 1] The cross section having shown the manufacture method of the semiconductor substrate ( GaN concerning one concrete example of this invention.
[Drawing 2] The cross section having shown the manufacture method of the semiconductor substrate ( GaN concerning one concrete example of this invention.
[Drawing 3] The cross section having shown the manufacture method of the semiconductor substrate ( GaN concerning one concrete example of this invention.
[Drawing 4] The cross section having shown the manufacture method of the light emitting diode concerning one concrete example of this invention.
[Drawing 5] The cross section having shown the manufacture method of the light emitting diode concerning one concrete example of this invention.
[Drawing 6] The cross section having shown the manufacture method of the light emitting diode concerning one concrete example of this invention.
[Drawing 7] Drawing having shown the luminescence property of light emitting diode.
[Description of Notations]
1 — Silicon on sapphire
2a, 2b — Interlayer
3a, 3b — Semiconductor layer (GaN)
4 — Buffer layer (n-GaN)
5—i layers, p layers
6 7 — Electrode
10 — Light emitting diode

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[Translation done.]